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APPLICANT : KUBOTA LTD;

INVENTOR : HORIUCHI YASUO;

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TITLE : A FURNACE WALL COOLING ELEMENT

ABSTRACT : PURPOSE: A said cooling element made to provide provide improved durability and thermal conductivity and permit easy manufacture.

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BOF replacement vessel at Iscor

Replacing an old converter shell with an exact replica is not the best way to improve productivity. Changes in shell design, however, need careful analysis to ensure that existing engineering can accommodate the changes. In this paper, Davy describe how they modified the suspension on two converters to take new shells.

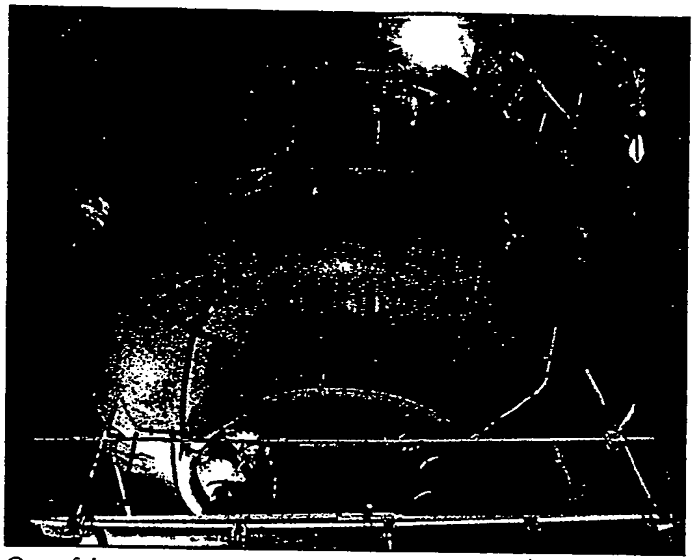
By D Bell, R Bailey,
M Hibbs & B Featherstone*

The Davy Corporation was awarded a contract in 1988 to replace the three 150t capacity BOF vessels at Iscor's Vanderbijlpark Works, South Africa. The contract was placed with Davy South Africa with the design and detailed engineering of the replacement vessels undertaken by Davy McKee (Stockton), UK.

The new converters were to feature a modified refractory lining and additional vessel cone cooling. These factors would affect the torque requirement of the drive. A visit was arranged to establish the detailed requirements of the client and a site survey was carried out. This established that the existing water cooled trunnion rings and tilt drives were in good condition.

If the trunnion rings and drives could be retained and re-used with the new BOFs then significant savings in capital cost, delivery, construction and re-commissioning time could be achieved.

The required drive torque curves were established for the replacement vessels (Fig 1). The relationship between the vessel centre of gravity and tilt angle was calculated using a Davy computer program, which takes into account the out of balance effects of the liquid steel bath and refractory lining wear. Using this information the existing drive was appraised for the new duty and was found to be acceptable.



One of three converters at Iscor's Vanderbijlpark works fitted with a modified suspension system.

Davy suspension system

The Davy vessel suspension system can be retro-fitted to existing trunnion rings. Such a retro-fit had been made previously to an existing BOF and trunnion ring on a plant in the UK.

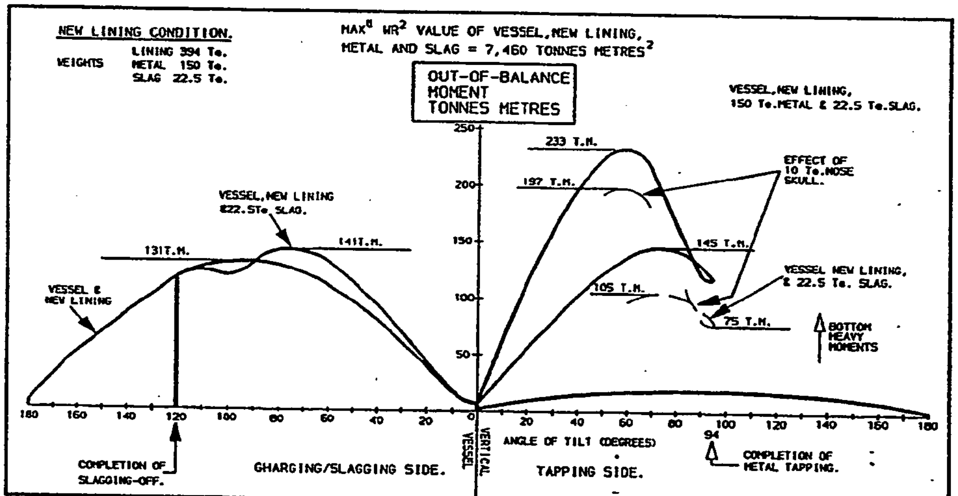
The principle of retro-fitting the suspension system to the existing Iscor trunnion rings was confirmed. A detailed design study was necessary to ensure the practicability and integrity of the retro-fit design. This study included a detailed stress analysis using finite element analytical techniques.

For design purposes, the BOF was split into the following parts: the vessel, the trunnion ring and the vessel to trunnion ring connection (the suspension system).

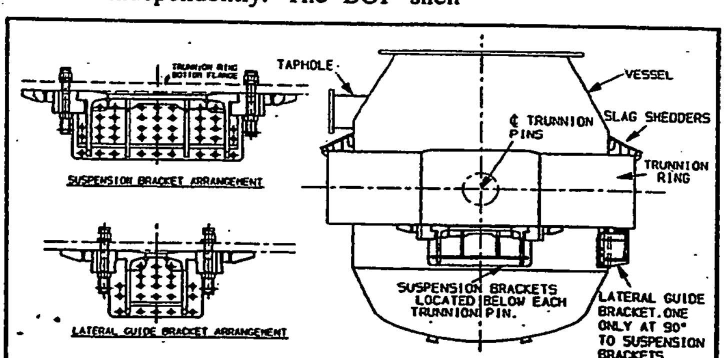
The suspension system comprises two brackets bolted to the shell and situated directly beneath the trunnion pins (Fig 2). These are attached to the underside of the trunnion ring by claws, which secure the BOF vessel within the trunnion ring, yet permit free expansion between the two components. A third smaller bracket is located at 90° to the trunnion pin axis. Its function is to keep the vessel central within the trunnion ring. The brackets are located in the relatively cool area of the vessel. This location also provides maximum protection to the components, particularly from vessel slopping, and permits easy inspection of the suspension members when the vessel is inverted.

For analysis purposes, these parts conveniently reduce to two systems which were assessed independently. The BOF shell with support brackets and the trunnion ring together with the attached claws. The load transfer path between the brackets and claws is dependent on the vessel tilt angle and a range of load cases was performed to assess the design (Fig 3).

In the upright position the vessel is supported on all four claw faces. In the horizontal position the loading is taken by the two lower claws on their side face. An additional load is present due to the vessel centre of gravity not lying in the plane of the claw support faces. This produces an additional moment which is reacted by equal and opposite forces; one between the lower claw support face and bracket foot, the other between the upper bracket foot and underside of the trunnion ring. In the inverted condition, the load is reacted between the bracket feet and the underside of the trunnion ring, with no load taken by the claws. At intermediate positions the vessel is supported by a combination of these load cases.



1 *The drive torque curve varies with the degree of refractory wear and the charge position.*



2 *Davy suspension system can be retrofitted to existing converters.*

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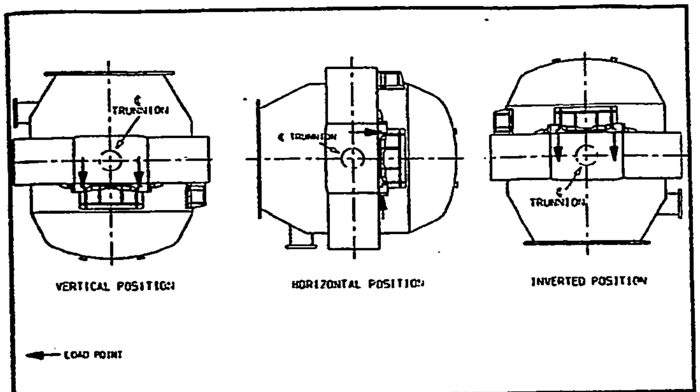
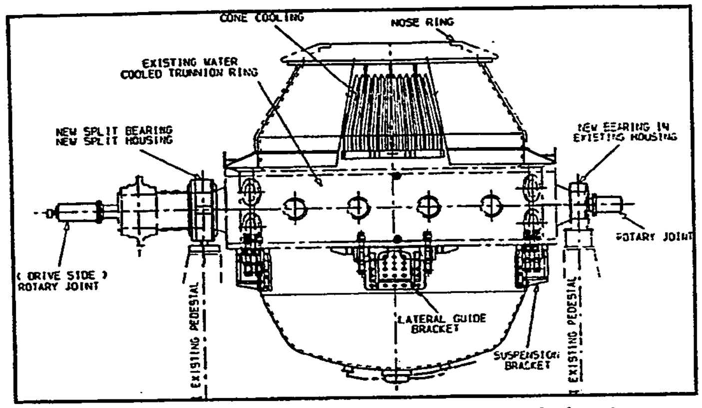


3 *The load transfer path when inverting the vessel.*



5 *General arrangement of BOF fitted with new split bearing.*

Trunnion ring design

The three load cases were simulated by applying loads at the relevant positions on the claw and the adjacent trunnion ring. At all times conservatism was adopted when choosing the locations for applying loads. As an example, the claw support face was never assumed to be uniformly loaded. Positions were chosen to maximise the effect on the trunnion ring and claw in order to ensure the integrity of the design.

BOF and bracket

A similar procedure was used for the vessel shell and bracket assembly. The three load cases were simulated by applying loading to the shell due to vessel self weight, refractory and charge, with the direction dependent on the tilt angle. Additional loading was applied to the shell due to the differential expansion from the refractory. As in the trunnion ring analysis, the bracket feet were supported at locations which maximised the loading in the assembly.

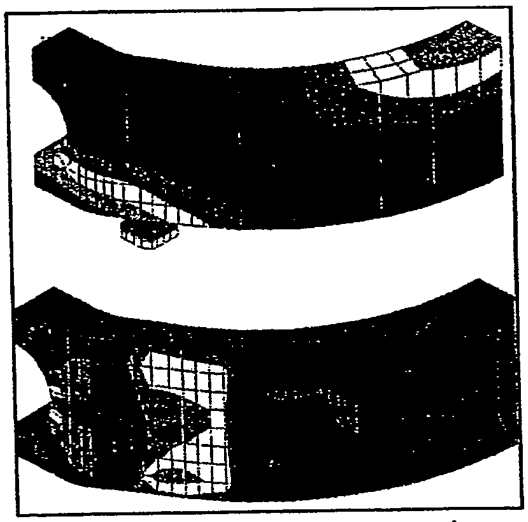
Using this procedure the detail design of the suspension system and modifications to the trunnion ring was effected (Fig 4).

Vessel cone cooling

Top cone cooling was required by the client in order to reduce the shell temperatures and extend the life of the magnesium carbon lining.

Cone cooling extends from just below the nose ring down to a level overlapping the vertical sided barrel section. Cooling is effected by water passing through angle sections welded to the vessel shell. These angles are grouped by headers at top and bottom to form six separate and parallel cooling circuits. The six circuits are fed from six pipes emanating from a rotary joint located on the outboard side of the converter drive shaft. The feed pipes, each with an individual isolating valve, pass through a hole in the drive shaft and then form ring pipes above the trunnion ring with six off-takes to headers located just above the trunnion ring. These headers feed the angle sections which form the cooling elements of the nose cone. Six off-takes from the outlet headers, each with an individual non-return valve, discharge into a return pipe. Discharge of water is via the rotary joint on the free side.

Isolation facilities in case of water leakage from areas of the nose cone are by means of the isolating valves in the feed lines and by the spring loaded non-return valves in the discharge pipes.



4 *Typical finite element stress contour plots on trunnion ring (increasing stress blue to red).*

System protection and safety

The Vanderbijlpark plant is susceptible to lightning strikes which frequently disable the electricity supply system. In the past converter cone cooling systems had been severely damaged during power supply failures. This was caused by the rapid expansion of the coolant, as the water converted to steam in the cooling channels as soon as the water pump stopped. This problem was resolved by the installation of a diesel pump which would automatically trip in on power failure.

To allow sufficient time for diesel pump start-up, a header tank arrangement was installed. A control valve opens in the event of a power failure and the tank can be isolated remotely at the end of a campaign. A restrictor orifice inserted between flanges in the downpipe controls the water flow during emergency operation such that effective cooling continues for up to five minutes, by which time the diesel pump will have had time to take over. When this occurs a non-return valve in the downpipe prevents reverse flow, the tank re-fills via a ball float valve, and effective emergency cooling continues until normal cooling is resumed.

Drive refurbishment

The gearing comprising the tilt drive was in good condition and did not need to be refurbished.

The drive side and free side trunnion bearings had to be replaced (Fig 5). This action would obviously have an effect on the timetable for on-site vessel replacement. It was considered unacceptable to replace the drive side trunnion bearings with the same solid type as supplied with the original converters as this would involve complete removal of the tilt drives. These bearings were replaced with split units. The new units were specified to ensure that their capacity was equal to, or better, than the original solid bearings. Split bearings have been used in this application, particularly in Europe, and have given satisfactory service. Examination of the existing bearing housings showed that they were not able to accommodate the new bulkier split bearings and therefore new housings were provided.

In order to remove and replace the lower half of each housing as a one-piece unit, the trunnion ring and drive would have to be jacked-up by more than 450mm. This was not considered practicable. During assembly each trunnion ring was jacked up a minimal amount and the bearing and lower half of the existing housing cut up to permit removal.

Each replacement lower housing was designed as a two-piece unit. The larger portion being slid into place and the smaller part bolted to it to form the complete lower housing, the joint line with the bearing cap remaining horizontal. This approach (which had been successfully used in the past) ensured that each complete tilt drive did not need to be disturbed.

Manufacture and installation

Manufacture of the vessels was carried out in South Africa to Davy specifications.

Site installation of all three replacement vessels was carried out by Davy. Consecutive installation of all three vessels was carried out between the end of August 1990 and the end of January 1991. The first vessel was put back into production early in November 1990. It was taken off after its first campaign having achieved Iscor's best-ever record of 2482 heats from one vessel.

In April 1991 Iscor produced an all-time shop record of 72 heats in 24 hours on two-vessel operation. ■

Acknowledgement

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(2,000円)

特　許　願　A

特許庁長官殿　　　　　　　　　　　　　　昭和50年6月14日

1. 発明の名称　ロヘキレイキヤクソタイ
炉壁冷却素体

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5. 添附書類の目録
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(2) 図面　1通
(3) 委任状　1通
(4) 願書の副本　1通
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明　細　書

1. 発明の名称　炉壁冷却素体

2. 特許請求の範囲

普通鋳鋼或いは低合金鋳鋼によつて形成され炉壁に接合すべき冷却板(2)中へ、一連の鋼製水冷管(4)の両端を冷却板(2)外面に突出させて一体に鋳包んだことを特徴とする炉壁冷却素体。

3. 発明の詳細な説明

本発明は溶解炉、高炉等の炉壁寿命を延長するため炉壁に密接して冷却する炉壁冷却素体に関する。

従来、斯種高炉用炉体冷却素体は、鋳鉄、低合金鋳鉄或いは球状黒鉛鋳鉄を以つて冷却板を形成し、この冷却板の鋳造時に鋼製の水冷パイプを一体に鋳包んで構成している。

しかし水冷パイプと冷却板とは材質が相異し、含有炭素量に著しい差があるため、鋳造時の溶融状態の鋳鉄材料が浸炭材となつて水冷パイプ表面に浸炭現象を起し、脆化させるおそれがある。又冷却板は高炉炉内温度変化による熱疲労のため、材料を劣化し予期された耐用年数を保持することが出来ず、又水冷パイプにクラッチ発生、グレージングを起して漏水することがある。

そのため従来は、製造時に予め水冷パイプ外面に浸炭防止のコーティング処理を施し、或いは鋳鉄溶湯の鋳込温度を規制する等、製作上種々の注意を要していたが、鋳包まれた水冷パイプは冷却板の材質に溶着せず、両者間に僅かのギャップ形成していた。従つて水冷パイプを流れる冷却水は鋼製パイプ、ギャップ、鋳鉄製冷却板を経て炉壁を冷却し、異材質間の熱伝達のため冷却効率は低下する等、種々の問題があつた。

本発明は、上記諸問題を一挙に解消して耐久性及び熱伝導性を向上し且つ製造作業の簡易化を実現した炉壁冷却素子を提供するものである。

以下図面に示す実施例に基づき本発明を具体的に説明する。

本発明の炉壁冷却素体(1)は、普通鋳鋼又は耐熱性、耐浸炭性を増すためにCr等の合金元素を添加した低合金鋳鋼を以て、炉壁への接合面(3)を内

面に具えた所望厚さ、面積の冷却板(2)を鋳造によつて形成し、該冷却板(2)の鋳造時、冷却板と略同一の線膨脹係数である一連の鋼製水冷管(4)を、その両端部(5)(6)を冷却板(2)の外面に突出させて鋳包み、冷却板(2)と水冷管(4)とを溶着させ一体化してなるものである。上記冷却板(2)には、吊金具(11)及び適所に両面に貫通するボルト孔(7)を開設し、炉壁(A)の鉄皮に取付け接合面(3)を鉄皮に接合保持すべくなすと共に、水冷管(4)の両端部(5)(6)には夫々ネジ部(8)を形成し、第2図に示す如く、冷却板を炉壁に取付けたとき、隣接冷却板(2)(2a)の各水冷管(4)(4)の端部(5)(6)間を接続管(9)、継手(10)を介して一連に接続するものである。

本発明は上記の如く、冷却板(2)は鋳鋼によつて形成されるから、これは鋳込まれる鋼製水冷管(4)と略同程度に低度の炭素含有量であり、そのため水冷管(4)の浸炭は起らず材量の脆化は防止出来、しかも両者の同系の金属材料であるから完全溶着が出来て水冷管(2)を流れる循環水は熱伝導によつて直接に炉壁を冷却し、冷却効果を向上する。又製造時に従来の如く浸炭の防止処理、注湯操作の規制等は必要でなく、製造が簡易となりスピードアップされて量産に極めて有利である。

更に本発明の冷却素子は、冷却板及び水冷管の両者が鋼製であり、略同一の線膨脹率であるから、耐熱衝撃性、耐熱疲労性が著しく高く、長期の使用に耐え得る等、多くの利点を有するものである。

4. 図面の簡単な説明

第1図は使用状況を示す断面図、第2図は第1図の一部を拡大した斜面図、第3図は第2図II−II線に沿う拡大断面図である。

(2)…冷却板　(4)…水冷管

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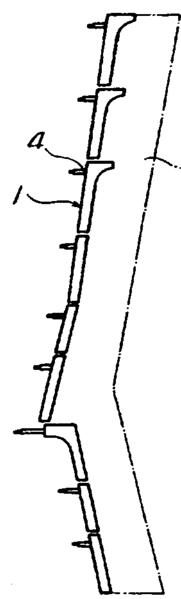
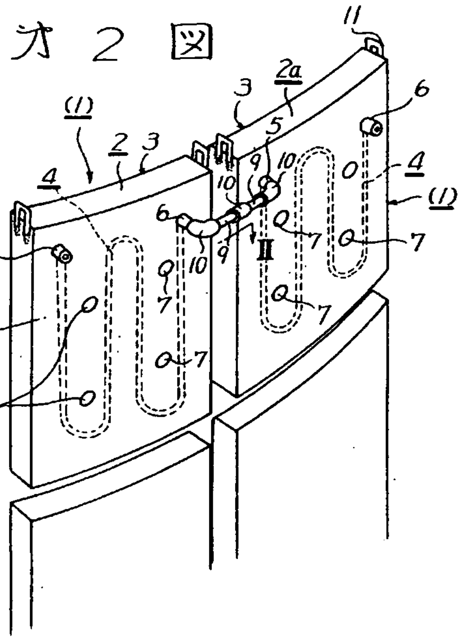
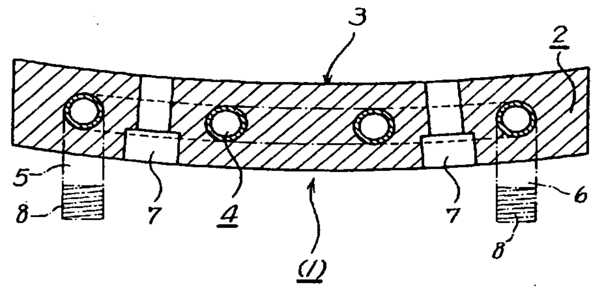
才1図



第2図



第3図



6. 前記以外の発明者、考案者、出願人、代理人

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